Lecture Notes in Electrical Engineering 365

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Editors

Proceedings of Second International Conference on Electrical Systems, Technology and Information 2015 (ICESTI 2015)

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Contents

Introduction

This book includes the original, peer-reviewed research papers from the 2nd International Conference on Electrical Systems, Technology and Information (ICESTI 2015), held during 9–12 September 2015, at Patra Jasa Resort & Villas Bali, Indonesia.

The primary objective of this book is to provide references for dissemination and discussion of the topics that have been presented in the conference. This volume is unique in that it includes work related to Electrical Engineering, Technology and Information towards their sustainable development. Engineers, researchers as well as lecturers from universities and professionals in industry and government will gain valuable insights into interdisciplinary solutions in the field of Electrical Systems, Technology and Information, and its applications.

The topics of ICESTI 2015 provide a forum for accessing the most up-to-date and authoritative knowledge and the best practices in the field of Electrical Engineering, Technology and Information towards their sustainable development. The editors selected high quality papers from the conference that passed through a minimum of three reviewers, with an acceptance rate of 50.6 %.

In the conference there were three invited papers from keynote speakers, whose papers are also included in this book, entitled: “Computational Intelligence based Regulation of the DC bus in the On-Grid Photovoltaic System”, “Virtual Prototyping of a Compliant Spindle for Robotic Deburring” and “A Concept of Multi Rough Sets Defined on Multi-Contextual Information Systems”.

The conference also classified the technology innovation topics into five parts: “Technology Innovation in Robotics, Image Recognition and Computational Intelligence Applications”, “Technology Innovation in Electrical Engineering, Electric Vehicle and Energy Management”, “Technology Innovation in Electronic, Manufacturing, Instrumentation and Material Engineering”, “Technology Innovation in Internet of Things and Its Applications” and “Technology Innovation in Information, Modeling and Mobile Applications”.

In addition, we are really thankful for the contributions and for the valuable time spent in the review process by our Advisory Boards, Committee Members and Reviewers. Also, we appreciate our collaboration partners (Petra Christian

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On behalf of the editors Felix Pasila

Part I
Invited Speaker

Chapter 60
Development of the Remote Instrumentation Systems Based on Embedded Web to Support Remote Laboratory

F. Yudi Limpraptono and Irmalia Suryani Faradisa

Abstract Web-based remote instrumentation is a new innovation in the development of instrumentation equipment that can be accessed remotely over the Internet. The development of remote instrumentation has been started since the invention of internet technology and the development of the remote lab system. Most remote laboratory system architectures that have been published are computer based and usually using LabView application. Computer-based remote instrumentation system has the disadvantages that the investment costs are expensive and it requires large electrical power. In addition, there are several issues related to green computing that demands increased efficiency. To address some of these issues, this research study has developed an embedded web-based remote instrumentation to support remote laboratory system. Implementation of the embedded web-based remote instrumentation system is expected to contribute to improving efficiency and lowering the system's costs.

Keywords Remote instrumentation · Embedded-web · Remote laboratory

60.1 Introduction

At the end of the 20th century, remote lab is a very active area of research in the development of e-learning, and recently the number of universities working with remote labs has increased [1]. There are several advantages of using remote laboratories, such as laboratory performance will be better and more efficient because students can use laboratory equipment for 24 h. A remote laboratory creates

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autonomous learning [2], allows uses by handicapped students [3], and supports resource sharing and collaboration between laboratories. Various technologies in web programming have been employed to provide a comfortable remote lab environment, such as socket, applet, ajax, corba, labview, etc. [3] Typically the design of the remote laboratory consists of several parts: the first is remote lab management, the second is an experiment module, and the third is the instrumentation equipment [2]. Remote lab management is a web-based application that serves to manage user permission and set up the equipment module. Lab module is an experiment object that can be controlled remotely, that is equipped with IP cameras for object observation. Instrumentation equipment is a device used for measurement or signal generation in the experiment modules such as oscilloscopes, frequency generators, etc. Currently instrumentation equipment widely used for remote labs is conventional measuring instruments or virtual instrumentation based on LabVIEW. Based on the results of journal reviews, it can be inferred that most remote laboratory research projects use a desktop computer, where the investment costs of hardware, software, and maintenance are very high. Electrical energy requirements for servers, computers, monitors, and cooling systems in a computer-based remote laboratory are very significant. A desktop computer requires electrical power on average between 60 and 100 W [4]. Energy consumption for a computer contributes to the rise in greenhouse gas emissions. Every personal computer that is being used produces about one ton of carbon dioxide every year [5]. Based on the background described above, this research aims to design and implement remote instrumentation to support remote laboratory, which has efficient system specifications and is environmentally friendly. Development of remote instrumentation includes the designs of oscilloscope and signal generator that are implemented with embedded system technology, which is expected to increase the efficiency of the system and support Green IT era.

60.2 Remote Lab Architecture

The proposed design of the remote instrumentation based on embedded web is integrated with multiuser remote laboratory that has been developed and published in the manuscript titled “New Architecture of Remote Laboratories Multiuser based on Embedded Web Server” [6]. Block diagram of the remote lab architecture is shown in Fig. 60.1. The activities of this research project are divided into two phases. The first phase is the design and implementation of some remote instrumentation system including an oscilloscope and a signal generator; the research activities have been carried out in 2015. The second phase will be the design and implementation of a matrix switch module; the research activities will be carried out in 2016. Matrix switches are a series of switches that can be programmed to connect between the experimental modules and instrumentation equipment. Remote instrumentation design is implemented using the embedded systems based on Raspberry PI.

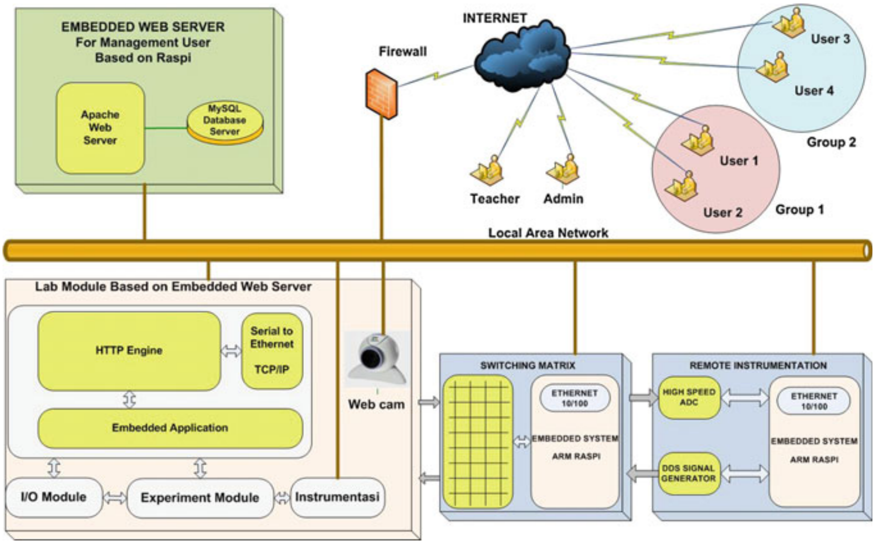

Fig. 60.1 Diagram of the remote lab architecture

60.3 Remote Instrumentation Design

The design of remote instrumentation, as shown in Fig. 60.2, consists of an embedded system based on Raspberry Pi, a DDS (direct digital synthesis) module based on AD9850, and a high-speed data acquisition system based on AD775. The

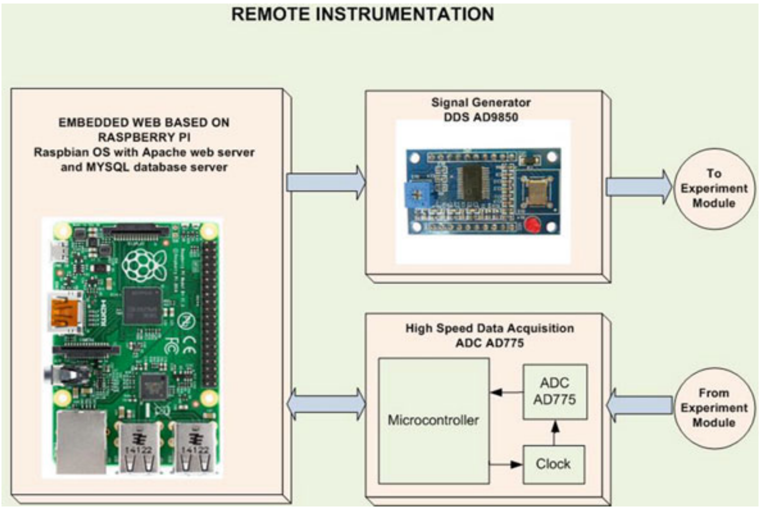

Fig. 60.2 Diagram of the remote instrumentations

Raspberry Pi embedded system functions as a web server to serve requests from the user of the remote lab and to control the DDS and the data acquisition unit. Raspberry Pi is based on the Broadcom BCM2835 system on a chip (SoC), that includes an ARM1176JZFS 700 MHz processor, 512 MB of RAM, and a storage capacity of 8 GB SD card. Raspberry Pi is also equipped with a GPIO, an Ethernet port 10/100 Mbps and a USB port [7]. The operating system used in this research project is embedded Linux Raspbian, and the installed application programs are Apache web server and MySQL database server. The design of the signal generator module uses AD9850. The AD9850 is highly integrated device that uses advanced DDS technology coupled with internal high speed, high performance digital to analog converter and comparator to form a complete, digitally programmable frequency synthesizer and clock generator function. High speed DDS AD9850 provides 32-bit frequency tuning word, which results in an output tuning resolution of 0.0291 Hz for a 125 MHz reference clock input. The AD9850 circuit allows the generation of the output frequency of up to one-half the reference clock frequency (62.5 MHz). The DDS circuitry is basically a digital frequency divider function whose incremental resolution is determined by the frequency of the reference clock divided by the 2N number of bits in the tuning word. The relationship of the output frequency, reference clock, and tuning word of the AD9850 is determined by the formula [8]:

$$f_{out} = (\Delta\, Phase \times CLKIN)/2^{32} \tag{60.1}$$

wheres:

Δ *Phase* is the value of the 32-bit tuning word
CLKIN is the input reference clock frequency in MHz
fout is the frequency of the output signal in MHz

The design of a digital oscilloscope uses high speed data acquisition based on AD775. The AD775 is a CMOS, low power, 8-bit data output, 20 MSPS sampling rate analog-to-digital converter (ADC). The AD775 features a built-in sampling function and on-chip reference bias resistors to provide a complete 8-bit ADC solution. The AD775 utilizes a pipelined/ping pong two-step flash architecture to provide high sampling rates (up to 35 MHz) while maintaining very low power consumption (60 mW) [9].

60.4 Software Design

The software of the remote instrumentation system is implemented using Python programming language, which is commonly used in embedded Linux operating systems. The following subsections will discuss the flowcharts for DDS AD9850 and data acquisition unit AD775.

60.4.1 Programming the DDS AD9850

The AD9850 contains a 40-bit register that is used to program the 32-bit frequency control word, the 5 bit phase modulation word, and the power down function. The interface between the DDS AD9850 with Raspberry Pi uses serial mode. In the serial mode, subsequent rising edges of W_CLK shift 1-bit data on Pin 25 (D7) through the 40 bits of programming information. After 40 bits are shifted through, an FQ_UD pulse is required to update the output frequency (or phase). Flowchart of the AD9850 program is shown in Fig. 60.3.

60.4.2 Programming the Data Acquisition

The remote oscilloscope unit consists of a data acquisition system and an embedded system based on Raspberry Pi. The data acquisition system consists of a micro-controller, a clock circuit, and ADC AD775. Raspberry Pi serves as web services for the remote oscilloscope. Acquisition process of the analog signal is performed by the data acquisition unit in real-time, and the data are stored in local memory of the oscilloscope. Periodically the data conversion results are sent serially to the

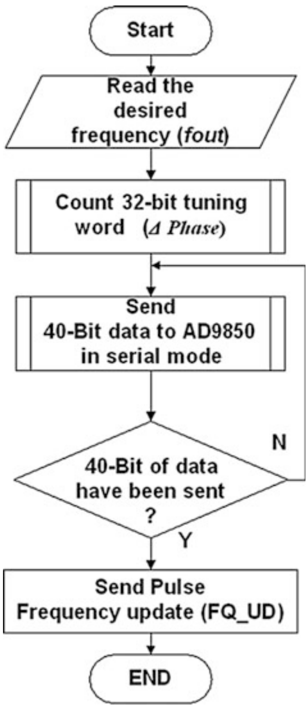

Fig. 60.3 Flowchart of the AD9850 program

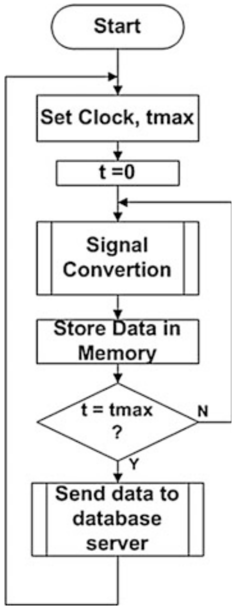

Fig. 60.4 Flowchart of the DAQ program

Raspberry Pi to be stored in the database server. Remote users can access the web services provided by Raspberry Pi to view the observed signals, and the signals will always be updated automatically. The flowchart of the DAQ program is shown in Fig. 60.4.

60.4.3 Web Application of the Remote Instrumentations

The Web-based remote instrumentation application was developed using PHP and Python programming languages. The application is used to control the hardware instrumentation, such as setting desired frequency parameters in the signal

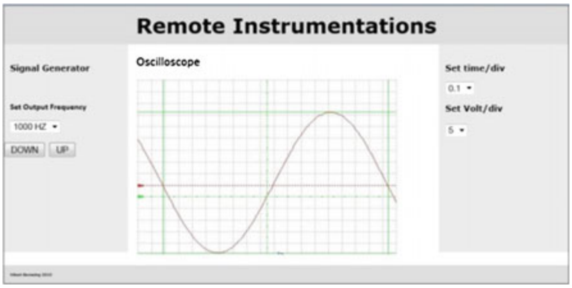

Fig. 60.5 Remote instrumentations web page

generator or setting parameters on the oscilloscope (time/div and volt/div), and produce graphic display on the client computer. The remote instrumentations web page is shown in Fig. 60.5.

60.5 Conclusion

This paper presents the development of remote instrumentation based on embedded web for supporting a remote laboratory. The aim of the research is to create a prototype of remote instrumentation—consisting of an oscilloscope and a frequency generator—that has highly efficient specifications: low cost, low power, and supporting Green IT. At the time of writing, the research project is still ongoing and the results are expected to contribute to the development of green remote instrumentation system. The instrumentations system can be integrated with the multi-user and multi-device remote laboratories that had been developed previously.

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